A Quality of Service Strategy to Optimize Bandwidth Utilization in Mobile Networks

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***Abstract* - The mobile network that supports network mobility is an emerging technology. It is also referred as NEMO (NEtwork MObility). It is more appropriate for mobile platforms such as car, bus, train, air plane, etc. It is a great challenge to provide Quality of Service (QoS) in NEMO. QoS is a set of service requirements to be met by the network. There are various parameters by which QoS is provided. This paper concentrates on providing optimum bandwidth for data traffic. The objective of this paper is to propose a strategy to use Virtual Circuit (VC) approach in NEMO. It helps to utilize the bandwidth effectively, to consume minimum time to transfer the data and also to reduce overload of the mobile router due to the minimum size of the header. Ultimately, it gives better results to enhance the QoS in mobile networks.**

***Index Terms* - Mobile Network, NEMO, Virtual Circuit, QoS,Bandwidth**

I. INTRODUCTION

Packet Switching is a method used in the digital communication networks which divides the content into blocks, called packets irrespective of its size, type or structure. During the travel through the network switches, routers and other nodes, the packets are buffered and queued, results in variable delay and throughput depends on the traffic in the network. There are two major packet switching modes. They are connectionless packet switching which is known as datagram switching and connection-oriented packet switching which is known as Virtual Circuit (VC) switching [1].

Virtual Circuit gains a lot of attention because of its congestion-controlled and delay-reduced approach for effective data transfer. In the datagram switching each packet includes complete addressing or routing information. The packets are routed individually and sometimes in different paths.

Mobile IP is an IETF (Internet Engineering Task Force) standard communications protocol that is designed to allow mobile devices to move from one network to another while maintaining a permanent IP. Mobile IPv4 is described in IETF RFC 3344 [2] and Mobile IPv6 is described in IETF RFC 3775 [3]. IPv6 is the next generation IP version designated as the successor to IPv4. The IPv4 uses 32-bit address space and IPv6 uses 128-bit address space. IPv4 and IPv6 have different address space and also different header format.

Whenever a packet is sent through the conventional Mobile IP from the source to the destination, at each routers an extra information is added in order to identify the next router and the path. If the number of intermediate routers is considerably high then the load of the packet will be increased at each router to a bigger size. This will cause delay in the data traffic and the traffic flow will be more critical.

In the virtual circuit switching, instead of adding the address information the VC identifier is added. The idea behind the virtual circuit is to avoid choosing a new route for every packet. Instead of choosing new routes, when a connection is established, a route is identified for all traffic flowing over the connection as part of the connection setup and stored in the tables of the routers. Each packet carries an identifier that tells which VC it belongs to.

This paper is organized as follows. Section 2 highlights the motivation to write this paper. Section 3 proposes a QoS strategy to utilize the bandwidth effectively. Section 4 presents the results of the proposed strategy. Section 5 gives the conclusion and future enhancements. Section 6 lists the references.

II. MOTIVATION

The datagram switching adds some additional information at each router. It causes delay and critical network traffic. The VC adds only the identifier information which doesn't take much space. Instead of adding more information like source and destination address at each router, simply adds the VC Identifier (VCI) will reduce the size of the header. The advantages of VC are connection-oriented services, Quality of Service is guaranteed, no congestion because resources allocated in advance, packets forwarded more quickly because no routing decision is needed, etc.

The VC can help to reduce the delay and to improve QoS in mobile wireless networks [4]. The increasing use of transferring multimedia applications such as voice, video and data needs the QoS support. Because Army moves organizationally, nodes in Tactical Internet (TI) have the characteristic of Group Mobility [5] and the topology of TI is not change tempestuously in mostly time. TI is an important part of military applications using Ad Hoc technology, which is the primary platform of tactical communication in the future war. So it is meaningful to set up the virtual circuit in TI, which not only provides end-to-end QoS but also implements end-to-end compression of packet header [6] to improve the efficiency of packet transmission.

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The success of virtual circuit in Mobile Ad hoc NETworks (MANETs) closely depends on the scheme of resource reservation at the Media Access Control layer. QoS routing protocols search for routes with sufficient resources for the QoS requirements, which work with the resource management mechanisms to establish paths through the network that meets end-to-end QoS requirements [6][7][8]. QoS routing is difficult in MANETs. The overhead is too high for the bandwidth limited MANET because there need to be mechanisms for a mobile node to store and update link information [9].

Multicast service in virtual circuit networks requires a communication path from a sending node to a certain number of receiving nodes. Thus, multicast calls are simultaneously set up in several directions. Consequently, the service processes in these directions become mutually dependent and a blocking in one group influences a blocking in other groups participating in the connection [10].

Delay-Sensitive Mechanism to Establish Route Optimization (DeSMERO) helps to increase the Quality of Service (QoS) in mobile networks with respect to delay. The service providers can implement our idea to provide better QoSs to the customers for delay-sensitive applications like video conferencing, telephony, etc., [11]. A novel technique has been proposed to predict reason(s) for deterioration in the QoS and to identify the algorithm(s)/mechanism(s) responsible for the deterioration. It also gives better results to improve the QoS and to improve the performance of the network [12].

Each network has different raw radio rates and user throughput. The actual throughput is always lesser than the raw radio data rates [13]. There is a great need to use bandwidth effectively which in turn increases the performance of the wireless network. In [14], detail analysis of various internet applications and wireless technologies with network parameters such as bandwidth, radio rate, user throughput, type of duplex communication system was done. It also relates internet applications, wireless technologies and network parameters to use the bandwidth effectively.

To sum up, providing QoS will be much more difficult in NEMO [15] (i.e. mobile network that supports network mobility) and so many factors or parameters are involved to provide QoS in mobile networks. As the mobile wireless networks starve for bandwidth, it is appropriated to propose a technique to utilize the bandwidth effectively.

III. A QoS STRATEGY

The proposed QoS strategy is based on ATM (Asynchronous Transfer Mode) networks. The header size of ATM is 5 bytes rather than 40 bytes in IP (Internet Protocol)-based networks. The Virtual Circuit (VC) approach uses the Identifier called as VCI (Virtual Circuit Identifier) to establish a route between source and destination. Whenever there is a request for the data transmission, a VC is established using VCIs. In other words, the route is established during the call setup using the VCI that is assigned to the intermediate channels. Now, all the packets are transferred via the established VC. It is possible that any mobile router may leave from the established VC. In such case, the VC is re-established and the data transfer is resumed. After the completion of the data transfer the VC will be terminated.

Steps involved in the strategy:

i. Determine number of channels in each link
ii. Assign Virtual Circuit Identifier (VCI) for each channel
iii. Establish the VC
iv. Start data transmission
v. If any mobile router is away from the VC then re-establish new VC
vi. Resume the data transfer
vii. Terminate the VC after the completion of transfer

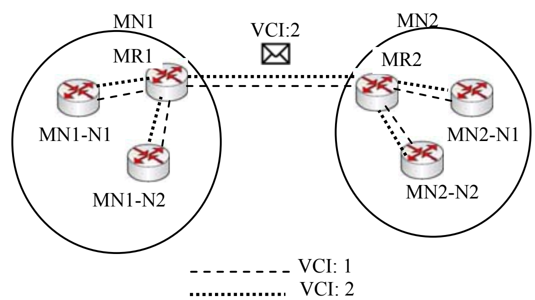

Figure 1. Example Mobile Network

Fig. 1. shows the proposed strategy for a mobile network. The VC is established between MR1 (Mobile Router 1) and MR2 (Mobile Router 2). Let us assume, the link between MR1 and MR2 has 2 channels. A MN1-N1 (Mobile Network 1's Node 1) can transfer data to MN2-N2 via one channel and MN1-N2 (Mobile Network 1's Node 2) can transfer data to MN2-N1 via other channel. Each mobile router maintains a table that has two major fields IN and OUT. The VCI is stored in these fields. The mobile router directs the packets based on the information available in the header and table. As the size of the packet header is 5 bytes, it is possible to transfer more packets via VC. In other words, the bandwidth used by the control data is greatly reduced from 40 bytes to 5 bytes. The remaining bandwidth (35 bytes / packet) used by control data can be used to send more payload.

IV. RESULTS

In the conventional Mobile IP, the sizes of the packets are increased at each router by adding extra information like source and destination addresses. The additional bytes will increase the delay and cause ineffective bandwidth utilization. These complexities will be further increased in nested mobile networks. At each router the packets are wrapped up with the header information in order to route the packet to the next router. Each router has to check the packets for the further action like deciding to which router it has to be sent. When the packet reaches corresponding peer router, it will unwrap the header information. The process of unwrapping and wrapping of the packets consume much time and causes more delay in the data transfer and also increases the load of the router. The

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proposed strategy uses the essence of the VC switching. The proposed strategy using VC approach is shown in the Fig. 2.

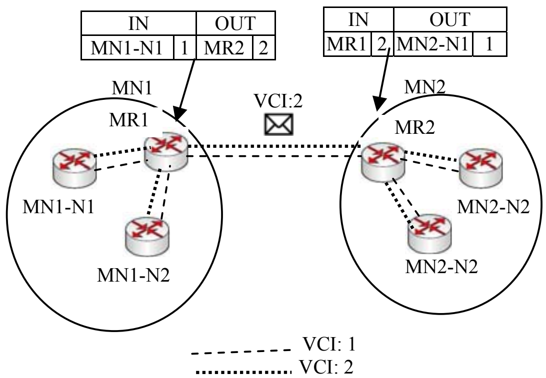

Figure 2. Proposed Method with VC Approach

The VC routing table maintained at MR1 and MR2 is given in Figure 2. It has two major fields such as IN and OUT [1]. The IN and OUT field have two subfields such as name of the node and VCI. If MN1-N1 wants to send data to MN2-N2, MN1-N1 establishes a VC from MN1-N1 ←→ MR1 ←→ MR2 ←→ MN2-N2. After VC is established, data transfer will take place.

Let assume that the link bandwidth is 1 MBps and Packet size is 512 bytes. The IP based network uses 40 bytes for header and ATM based network uses 5 bytes for header. Each packet saves 35 bytes and it can be used for payload. Using 1 MBps link bandwidth, 2048 packets of 512 bytes each can be transferred. In IP based network, 40 bytes header information is used for all 2048 packets. Consider the following calculation.

Number of packets (NP) = 2048
IP header size (IPH) = 40B
ATM based network header size (ATMH) = 5B

Total bytes used by header information in IP-based network (IP_Total)= NP X IPH

IP_Total= 2048 X 40B = 81920B

Total bytes used by header information in ATM-based network (ATM_Total) = NP X ATMH

ATM_Total = 2048 X 5B = 10240B

Hence, IP_Total = 8 X ATM_Total

The above calculation reveals that IP header information consumes 8 times of bandwidth than VC approach. In other words, 7 times of extra bandwidth can be saved if proposed QoS strategy is used.

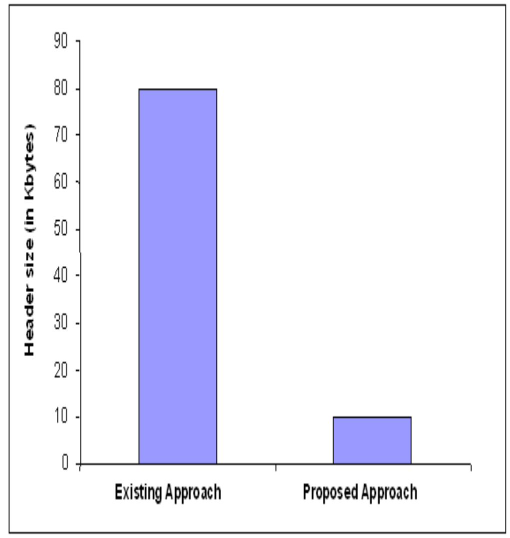

Figure 3. Bandwidth Utilization for Header Information

Figure 3 reveals that the existing approach uses 7 times of extra bandwidth for header information than proposed approach. The proposed strategy takes less time to process a packet, reduces the overload of the mobile router. This leads to effective utilization of bandwidth.

CONCLUSIONS

The great challenge for mobile networks is to provide QoS. Due to the mobile nature, providing QoS becomes complex in mobile networks. As the users of mobile technology are increasing significantly, there is a great need to reduce the complexities involved in providing QoS. There are various factors involved to provide QoS. One such factor is an effective utilization of bandwidth. The proposed QoS strategy uses VC approach in order to utilize the bandwidth effectively. In other words, bandwidth utilized by header information is greatly reduced and that bandwidth can be used by payload / data. The proposed QoS strategy helps to consume less time and causes minimum delay in the data transfer and also reduces overload of the router due to the minimum size of the header. Ultimately, it increases the throughput and performance of the mobile networks. Though this paper provides some advantages, it has weakness as well. Due to the mobile nature, the VC has to be re-established whenever a mobile node is away.

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